

**Ikhana and PUMA NWHI Post Mission Quick Look Review
July 25, 2014 - Minutes and Actions**

Overview: Following two flights last week to the Monument, this review is an open forum to discuss initial impressions, access to the data, plans and process for data analysis and reporting, the development of journal articles and next steps for NOAA UAS in Hawaii. Todd Jacobs opened the meeting by recognizing the first ever NASA deployment of Ikhana and noting that the last RIMPAC flight was still underway. For reference (not presented at the meeting), Ikhana flew two NOAA missions and five RIMPAC missions. It flew most of the way to Nihoa to verify communications during the RIMPAC check flight on July 7th. It flew a 9.9 hour mission over Nihoa on Thursday, July 17th at 20,000 ft altitude with a USCG C-130 chase, but lost satcom coverage when headed towards Necker. It flew a 9.4 hour mission over Necker without chase, under ground based radar observation on Saturday, July 19th, but lost satcom coverage 33 miles short of FFS. A summary of missions is attached. Participants included:

<p>Todd Jacobs, NOAA/OAR/UAS* JC Coffey, NOAA/OAR/UAS John Del Frate, NASA AFRC* Larry Camacho, NASA AFRC* Dennis Hines, NASA AFRC Lee Medley, NOAA/OAR/UAS Phil Hall, NOAA/OMAO Robbie Hood, NOAA/OAR/UAS Jim McCormick, NOAA/OAR/UAS</p>	<p>David Graham, NOAA/ONMS/PMNM* David Swatland, NOAA/ONMS/PMNM* Chad Yoshinaga, NMFS/PIFSC* Samantha Brooke, NOAA/NMFS/Monuments Dave Nekamoto, Ni'ihau Mark Manuel, NMFS/PIFSC/CRED* Kyle Koyanagi, NOS/ORR/MDP* Michele Kuter, USFWS/HINWR</p> <p>*present at the Inouye Regional Center (others by phone)</p>
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Ikhana Mission Overview: Todd described the successful deployment of Ikhana as precedent setting. While visibility was limited during the first flight, good scientific data was collected over Nihoa and Necker islands. There were also a couple of important hours of observation over the Island of Ni'ihau - the power of the Ikhana optics was quite evident and the island is a wonderful analog to the more remote islands. Thanks to the Robinson family ranch for their support; it also turns out that they are interested in remote sensing data to help manage their resources on the private island.

While Ikhana was not able to fly all the way to French Frigate Shoals due to satcom limitations, we did observe a composite of tall island terrain, including sandy beaches on Ni'ihau. There is no telemetry overlaid on the Ni'ihau imagery because the agreement that allows us to image the island includes a requirement to share products with the ranch, and the telemetry is DoD sensitive.

Airspace issues were not really representative. Chase provisions were a challenge, but a chase requirement is a non-starter for real operations. Airspace designation was also a problem, and the late approval of the COA left us little room to negotiate, but this should improve with experience.

Potential to support monument operations: David Graham commented that he was surprised by the quality of the data from the GCS - the video was fantastic. He has 14-16 hours of video footage in 20 minute files. He saw it real-time, but still needs to go through and annotate events of interest. Not sure how yet to share the review and distribute the files to the different projects. He also has MATLAB files of telemetry data to work with. He hasn't seen any radar data yet.

Radar Products: Todd mentioned that there were very few radar contacts. They saw a couple of interesting artifacts going out on the second flight, but were not able to get close enough to image them. Not sure what we might have seen. John Del Frate will check to see if we can get representative radar and imagery of vessels from RIMPAC missions. Todd said that Grant (radar operator) had said he could burn radar video. There was a good ISAR view of the Robinson's landing craft underway in the channel between Ni'ihau and Kauai. John said the radar is theoretically unclassified. The military was very impressed and saw surface data they've never seen before.

EO/IR Products: Todd said Raytheon mentioned that there is a new version of the MTS-B with HSI (hyperspectral imagery) and Lidar capability. John noted the current EO/IR sensor is high definition, but only broadcasts standard resolution. HD requires twice the data rate, and ground station modifications would be required. NASA has sharper versions of images downloaded directly from the aircraft.

Payload Control: Todd mentioned that when they had to turn back 33 miles short of FFS due to satcom limitations they could not control the skyball, but they could [still see the imagery?]. John said they could control the sensor from CONUS. He said if we do this again we should have the scientists work directly with the sensor operators. The flow of information went from the scientists to Walt on Ford Island, to Todd on Kauai, to the operators. There was a time lag and significant risk of misinterpretation. Chad said they could not communicate in time to affect the observations as they came.

Platform Control: Todd said they had to fly 50% faster than we would like on Thursday to match the minimum speed of the C-130 chase. Over Ni'ihau, without chase, they were able to control speed and altitude better. Walt Klein felt that flight at 4,500 to 8,000 ft provided an optimized view. David Swatland asked about the effects of haze - Thursday's video looked foggy. David Graham reported that Saturday's video looks crystal clear. David Swatland suggested atmospheric conditions should be taken into account for scheduling. [Chad?] also noted the difference in image quality between morning and afternoon. Todd explained that there was little ability to deal with altitude changes. Communicating with Oceanic control involved 30 minute cell-phone relays, and we couldn't have done it without USCG support. We need more

days available on the schedule so we can fly on the best days for visibility. In this case, we were out of calendar time and there was bad weather coming. NASA really pushed through a lot of perceived risk to make this mission happen (starter-generator issues). If we do this again we need a longer flying window and realistic crew coverage. We should think about the challenge of flying out to Midway and back vs. landing at Midway (for crew rest).

Airspace: David Swatland said the COA process was very frustrating and seemed to lack consistency. John said that operating under due regard would transfer responsibility from FAA to NASA. We should go back and explore what it would take to operate that way. There was also an interesting dynamic between FAA local and headquarters officials. As we got talking, more options became available, and the locals were able to say more than headquarters. There were also differences between Oakland and HCF. The COA generally includes the provisions that NASA requests, and with this experience we can ask for more flexibility next time. We learned a lot this time around, and we still have a lot of homework to do. Robbie Hood referenced a recent briefing on the new FAA test center. Eventually the AK/HI/OR test site could be in charge of COAs. They are not ready yet, but they are establishing a high altitude corridor for UAS. Todd said this should apply to all COAs, including Puma. Our COA has provisions to go all the way out to Kure Atoll. We also need to learn how much to push back on FAA. John described how they had to amend the COA last Tuesday. They gave the “FACS/FAC” guys new coordinates, who called DC and in a few hours they had an approved pen and ink change. We flew the new route the next day. We were surprised that we pulled it off.

Observations: Todd mentioned that we collected valuable data from Mokumanamana and Nihoa. We observed monk seal pups that would not have normally been seen as black fur on dark coral, but we could see them with IR from 20,000 ft altitude. Chad said he could clearly see a nursing pup from four miles up and over ten miles away. Samantha Brooke asked if you could see tags or bleach marks. Chad said no, but he thinks we could from lower altitude. Todd asked if the value of this kind of imagery varies with season. Chad said yes, any time there are no people in the field this would be valuable, especially in the summer when the seals reproduce. Winter is also an important season. David Swatland said vessel monitoring would also be more important in the winter, since there is more traffic. David Graham said there is also considerable interest in cetacean data in the winter. We just don’t know what’s going on then. There is a team working on a project involving a glider with hydrophones. David Graham said he saw some marine debris, but it was all on the beach. Kyle Koyanagi said it was unfortunate we did not get out to FFS. In the future we would really like to get out to Pearl and Hermes and the other northern islands that have more debris density in shallow coral reefs. We saw potential for the marine debris mission, but it is far from proven.

Cost: Todd stressed the importance of partnerships to make deployments of this class of UAS affordable. General Atomics is exploring new concepts, including a potential partnership with FEMA, and noted that the USCBP Mariner Predator fleet supports FEMA and has also supported NOAA tasking with six missions. Robbie explained that was for the North Dakota River Forecast Center during the spring floods. John suggested that nobody can afford to fly Ikhana to Hawaii themselves, so they are trying to line up additional partners and look for ways

to lower cost. NASA was surprised by shipping costs. They had to pay extra for cranes, forklifts, etc. They're suffering sticker shock, and they still need to send the system back. Maybe we can change the footprint. Larry Comacho is looking at other ground station options. These investments require long-term partnerships. For example, the Navy wants to fly every day. NOAA wants more than two days so they can schedule around the best weather. We really can't even guess at the cost of coming back. Larry said we have little insight into the daily costs of hosting the system at PMRF. John expects the base support we got for free is worth \$50-80K per day. We need a more optimal location. FAA wants us at PMRF, but we'd rather be at Barbers Point. Another possibility is to locate a launch and recovery element at Midway - though we can't do that yet. Someone asked about operating from the mainland. John said we could technically do that, but we would still need someone local to launch and recover. Time delays can be a problem. NASA is planning to deploy two predators from CONUS in the near future. Longer days don't buy you much because most missions are just daylight. David Swatland said Marine Domain Awareness would be valuable at night. Robbie Hood asked about the other RIMPAC partners and how they overlap with USCG. NASA, NOAA, 3rd Fleet, General Atomics, Raytheon (provided radar), AF (provided EO/IR). Todd expressed great thanks to Barry Choy for helping to pull this together.

Discussion and Lessons Learned: Michele Kuter said thanks on behalf of USFWS. This was more than they could have imagined. The imagery in the ground station left her in awe. Seabirds would be great to observe in the winter. She could clearly see frigates and rubies - winter is peak season for the larger seabirds. Winter observations would be huge for USFWS and give us a better idea of the overall population. Michele really wants to see the the footage from Mokumanamana. Justin (General Atomics) provided Nihoa [or was that Ni'ihau?] video, and we're using software to enhance the images and evaluate vegetation. Haven't seen the enhanced images yet. Not sure what the impact is of not having metadata.

Chad Yoshinaga would like to define better survey criteria for the operators to follow. They generally focused on a seal for 10 seconds and moved on. We would like to see different angles, etc. John agreed with this - the sensor operator needs better situational awareness of the observation needs. We need to optimize this up front.

Robbie Hood asked, if we want to do this again, given the expense, can we look at a test flight from California to pick up the missed objectives, maybe next year to support another deployment in FY16? Todd pointed out that the original plan included test flights in the Channel Islands, but the schedule didn't support it. If we are going to do this again the future we have to consider availability of the borrowed payloads. John said a lot of people wanted to fly in California, but we just ran out of time. We believe that would be far less expensive. Access to COAs, Chase, NAVAIR Warning Areas - the opportunities are there. We would need to have a conversation soon to pull off access to the radar, but we can hold on to the sky ball.

David Graham noted that what little radar he saw was amazing.

Todd asked about support to the Turtle program. Chad explained that turtle counts are not so valuable. Imaging nests at night might be useful, especially when no one is on the ground.

Data Issues: David Graham has received the Ikhana data from General Atomics, but hasn't even tried opening it yet. John asked about cultural sensitivity. David Swatland explained the need to complete an internal review first. We have shared lots of Puma data, but Ikhana got some close shots of sensitive sites, which we will need to redact. NASA will embargo all data from Nihoa and Necker. John mentioned that the Navy has a composite video from some flights, mostly from Nihoa, including a buoy on the beach. NASA will provide a copy of this "best of" product to the monument staff to double check, even though it is highly unlikely that it contains anything sensitive. David Swatland said that the concern for Puma was burial caves on the cliffs, but for Ikhana there is more concern for the top of the island. On the footage from Thursday's mission three sides of a totem wall were clearly visible. On the other hand, the Office of Hawaiian Affairs representative appear to be open to more video use. There is good potential to recognize the resource management value of this video and build trust in our proper use. Todd said we'll have to lean on the monument staff again to navigate these issues.

Image Quality: JC Coffey asked how we determine what resolution is good enough. Chad noted that some of the Ikhana imagery of Nihoa from 20,000 ft was better than imagery of Niihau from 4,000 ft. He thinks Ikhana could have captured bleach marks from 10,000 to 5,000 ft. Robbie asked about the tradeoffs between weather and altitude. What is the toolkit going to be for making these decisions? Maybe we fly a high altitude platform once a month and lower altitude systems more regularly. Todd noted that we can image Niihau any time, but low altitude access to the remote islands is limited by ship schedules. He also noted that we aren't yet addressing the value of the data actually observed. Mark Manuel? explained that the available planning tools are generally designed for applications different from our missions. A valuable concept would be for higher altitude systems provide recon for smaller ones. The hexacopter, for instance, can't survey an area, so it could be cued by a Puma. The tradeoffs should support the best use of people on the ground, to make their work more efficient.

Publication of Results: Todd asked Samantha about her plans to coordinate a journal article. She plans to pull together information from the analysis of alternatives directed towards a general audience to recognize the success, capture lessons learned and speculate on new sensing capabilities. She wants to facilitate documenting the things we've accomplished for reference. Robbie asked in what journal she would publish. Samantha said she initially considered an industry specific journal, but now they're looking for a more general audience. She also mentioned the article that OAR published.

Conclusion: Todd closed the meeting per schedule. We will have a Puma post-mission review on another day. We will continue to measure interest in future missions - stir the pot to see what adds value. David Swatland said that if we want to come back, the monument will support. We've proven some mission capabilities and we still need to see for others. The monument can't provide funding, but they will dedicate staff time and coordination.

Mission Summary:

Flt No	Date	Eng Start	Take Off	Land	Eng Off	Flt Dur	Purpose
164	7/07	0619	0703	1544	1550	8.8	RIMPAC: Ops Check and HADR
165	7/12	0609	0647	1211	1221	5.5	RIMPAC: W-192
166	7/17	0559	0651	1636	1645	9.9	Monument/AMC-21: Nihoa
167	7/19	0611	0700	1616	1623	9.4	Monument/Horzons1: Necker and Ni'hau
168	7/23	0603	0639	1614	1623	9.7	RIMPAC: DCA D2
169	7/25	0752	0818	1644	1652	8.6	RIMPAC: W-188 PhotoEx (No COA Required)
Total						51.9	6 Flights: 4 RIMPAC + 2 Monument